

Storage and Disposition of Nuclear Materials

Introduction

Due to the international movement toward the dismantling of nuclear weapons as a result of the Nonproliferation Treaty, the President of the United States has declared 200 tons of weapon fissile material (plutonium) as excess for inspection and storage. Similar efforts have been made by the former Soviet Union. As a result of their combined efforts, the world is now concerned with the monitoring of the excess radioactive material to ensure that it is stored properly, inventoried, and kept out of the hands of rogue nations. This has become even more important with the addition of India and Pakistan to the list of countries possessing nuclear weapons.

In addition to the excess radioactive materials from dismantled nuclear weapons, we must also be concerned with radioactive materials from nuclear power plants, industrial uses, university research, and medical facilities.

Radioactive waste materials are classified in five categories; Low level waste, low level mixed waste, Transuranic waste, high level waste, and hazardous waste. As we investigate the various options for disposition of these types of waste, we will have to learn the make-up of each, what the hazards are, and the type/level of radiation given off by each. We need to inform ourselves of the different types of radioactive materials that are used today and of those used in the past. We need to consider issues of security, proliferation, terrorism, energy needs, environmental, safety and health. We need to look at existing laws and regulations governing radioactive materials. Only through this knowledge can we make informed decisions as how to handle each type of waste.

A little over 50 years ago, work at Los Alamos and elsewhere in the world set in motion developments in military and civil applications of nuclear science and technology. Over the years these ongoing developments have shaped history. The resulting "Nuclear Age" has had a significant impact on many aspects of society -- nationally and internationally.

As a result of the initiative to develop a nuclear weapon to turn the tide in favor of the Allies in World War II, many radioactive materials were created as by-products of the Manhattan Project. It then became necessary to control these materials. The attitude toward nuclear weapons at that time was captured in the following quotation:

"We are here to make a choice between the quick and the dead...Science has torn from nature, a secret so vast in its potentialities that our minds cower from the

terror it creates. Yet terror is not enough to inhibit the use of the atomic bomb... We must provide the mechanism to... preclude its use in war."

- Joseph Cirincione

Current History: A Journal of Contemporary World Affairs, May 1995

These words contained the recognition that the control of radioactive materials would be a significant problem for the world. The United States and Russia had control of most of the radioactive materials in the early years of weapons research and development, but radioactive materials were considered powerful and attractive to countries who also wanted military power. It was the fear and interest in such a potentially dangerous material which led to the development of an international movement toward the dismantlement of nuclear weapons. The result was the Non-Proliferation Treaty (NPT). The world treaty signed in 1970 called for the control of nuclear weapons, but the NPT has not been the complete answer to the problem of controlling radioactive materials.

For example, in testimony given at the U.S. Foreign Affairs Committee hearing in March, 1993, the panel reported that the following countries are to be known nuclear weapons powers: the United States, the Former Soviet Union (FSU), Belarus, Kazakhstan, the Ukraine, the United Kingdom, France, and China (India and Pakistan can now be added to this list). Meetings among the nations have been recently held to make Russian warheads safe from terrorists. Brazil, Argentina, and South Africa have the capabilities but have renounced their weapon's programs. Two other nations, Iraq and North Korea, are suspected of having nuclear weapons capabilities, but since they refuse to conform to the terms of the NPT, it is difficult to know exactly what their status is.

The question is: What should be done with the excess radioactive materials from the dismantlement of nuclear weapons? Related to the question are other concerns such as: How should these materials be inventoried and monitored? How should they be kept away from rogue nations? How will the environment be safeguarded from contamination by those materials?

Task Assignments for Storage and Disposition of Nuclear Materials

Task #1 – Use of Radioactive Materials

"Nuclear materials present the capability of mankind to destroy itself,"

"So I hope all of you are working in this important field.

... we want to strengthen the spirit of cooperation for the security of mankind."

- Vladimir Shmelev, deputy director of the Kurchatov Institute's
Division of Nonproliferation and Control - 1995

Radioactive materials have many uses, from benign uses creating light for runways and exit signs, to highly destructive uses as epitomized by nuclear weapons. Röntgen first demonstrated the release of energy from a substance with a cathode ray tube. This discovery would send the world of physics into the modern age. The 2300 year-old concept of the atom was about to change. As other physicists began to unravel the mystery of the atom, the unsplittable particle would soon become splittable. Einstein released the genie with the publication of his famous equation stating that energy was equal to the mass of an object times the square of the speed of light. With this simple equation, Einstein demonstrated that energy and mass were just two facets of the same thing.

Our first task focuses on the use of radioactive materials. From commonly known uses of radioactive materials, the production of energy, and the development of nuclear weapons, other peaceful uses of the materials are sometimes forgotten. Using these as reference points, focus your research in relation to the multiple uses of radioactive materials as they relate to the four domains (scientific, economic, political, social/cultural).

"Peaceful applications of nuclear energy -- and all the promise they entail for humanity -- are paradoxically often perceived in juxtaposition with the prospects of nuclear weapons' proliferation and nuclear war. The mixed perception is understandable: the materials, knowledge, and expertise required to produce nuclear weapons are often indistinguishable from those needed to generate nuclear power and conduct nuclear research."

- by Mohamed Elbaradei, Edwin Nwogugu, and John Rames

Your task is to compare and contrast the endeavors of nuclear science and technology for "peaceful and military" uses.

You must examine how nuclear science and technology today is used. Scrutinize these uses in the context of the four domains (science, economic, social/cultural, and political/geo-political). Research and gather data that help you build an understanding of the uses of radioactive materials.

This task focuses on the use of radioactive materials. Using this as your reference point, address the following:

- 1.** Identify the varied uses of radioactive materials. Create a chart listing each use, the type of radioactive material used, the type of radiation given off by the nuclear material, the type and amount of shielding needed to protect users, and the specific applications for which it is used. What are the pros and cons for each use?
- 2.** Compare the production of energy in nuclear power plants with that in nuclear weapons?
- 3.** From the perspectives of pro- and anti- nuclear energy advocates, develop materials to be presented at a rally defending each groups agenda on the use of radioactive materials.
 1. Develop a critical analysis of the continuance of producing electrical power with fossil fuels.



Suggested Classroom Activities for Task #1

The following activities and questions are "hooks" for the work which is to come. While they are intended to generate discussion and promote understanding of and interest in the task, they are not directed specifically at any task question.

This task focuses on the use of radioactive materials. Using this as your reference point, address the following:

- 1.** Have a mock class dialogue between the Secretary of the Department of Energy and the president of "Citizens for a Safe World" (CFW) on the subject of using radioactive materials in the public sector. Have your students identify possible agendas for the CFW and develop a number of scenarios between the two debaters. Assign one student the role of Secretary Richardson and another the role of the CFW president. Each student should prepare themselves to prevail at the end of the debate. Both sides should have supportive members to supply needed documentation for the debate. A judging panel made up of other students will decide on the winner of the debate. Each student might present "visuals" which capture and categorize their ideas while convincing the panel members of their point of view. Be sure to consider the four domains (political, scientific, social/cultural, and economic) in developing arguments.
- 2.** Develop comparative charts identifying new technologies developed for medical uses of radioactive materials. Refer to each of the domains (How did the new technology affect each domain?). What are the benefits, the hazards for each use?
- 3.** Give examples of industrial uses of radioactive materials.
- 4.** Develop and conduct a survey to determine your communities perception of uses of radioactive materials. Interpret the results of the survey. What conclusions do you draw?
- 5.** Describe in your own words the responsibility a government has to the general population when it comes to using radioactive materials for private industrial use?
- 6.** As the public relations officer of the "Municipal Hospital", prepare informational materials like brochures, bumper stickers, position papers, and TV and newspaper ads delineating the future needs of the hospital for purchasing and using radioisotope technologies and testing equipment for a newly planned nuclear medicine wing of the hospital. Refer to benefits as they pertain to the four domains.
- 7.** As a study group within President Clinton's scientific advisors office, you have been researching the legacy left by the development of nuclear technology, including errors and accidents during the "Cold War". Your present task is to develop a strategy for disseminating the results of your research and the plan to expand the use of radioactive

materials in the public sector. Design a plan for transferring this information to each of the fifty states regulatory committees.



Task #2 – Types of Radioactive Waste

"Dr. Bertram Wolfe, a respected statesmen in the field of nuclear energy (retired corporate executive with General Electric and former President of the American Nuclear Society), once said that judging nuclear energy from the standpoint of the waste issue was a bit like judging the merits of parenting from the vantage point of the diaper. Any system (human or mechanical) that results in some useful output also generates waste. so the question is not whether waste exists; rather, it is the net cost of dealing with the waste, both in terms of health effects and environmental impact."

He went on to say, "...that one of the great advantages of nuclear energy is that the waste problem is so easily solvable. In fact, nuclear energy may be the first large industry in history that is capable of removing essentially all its waste from the biosphere."

(from *America the Powerless*, Alan E. Waltar, pg.108)

The greatest fears arising from skeptics of using radioactive materials are (1) what radioactivity will do to us and our unborn generations, (2) how do we keep it from exploding, and (3) what do we do with the waste materials after we use it. Although other aspects of nuclear energy stir the emotions, radioactive waste bothers most people. Skeptics would also point out: If the radioactivity can really last thousands of years, won't we be in danger? And if we could convince them that radioactive materials could be safely removed from the environment, they would then question the safety of transporting the materials to sites where they can be adequately disposed.

Our second task focuses on the types of radioactive waste and radioactivity. To understand what is meant by radioactive waste, we need to look at the makeup of the waste, the volume of such waste, and the longevity of the radioactive decay process before we can begin discussing how to dispose of it. Using this as reference point, focus your research in relation to the types of radioactive wastes as they relate to the four domains (scientific, economic, political, social/cultural).

Your task is to compare and contrast the different categories of radioactive wastes. You must examine how radioactive wastes are produced, how they are stored and eventually disposed. Scrutinize the importance of characterizing radioactive wastes in the context of the four domains (science, economic, social/cultural, and political/geo-political). Research and gather data that help you build an understanding of the uses of radioactive materials.

This task focuses on identifying radioactive wastes. Using this as your reference point, address the following:

- 1.** Identify and characterize the three forms of ionizing radiation. What inconsistencies exist in the general populations understanding of radioactivity and radioactive hazards?
- 2.** Distinguish between the general populations understanding of ionizing radiation and non-ionizing radiation and the scientific facts about each.
- 3.** Identify and characterize the 5 major categories of radioactive wastes.
- 4.** What are the implications (within the four domains) of the definitions for each type of radioactive waste?
- 5.** Compose a magazine article, complete with pictures, quotes, text, informing the general population about radiation and radioactive wastes. Include the science, health and environmental hazards and/or benefits.



Suggested Classroom Activities for Task #2

The following activities and questions are "hooks" for the work which is to come. While they are intended to generate discussion and promote understanding of and interest in the task, they are not directed specifically at any task question.

This task focuses on radioactive wastes and radioactivity. Using this as your reference point, address the following:

1. Create a series of charts/graphs depicting the amount of radiation (percentage of total radiation an average American is exposed to each year) from the following sources:

Natural

- terrestrial
- cosmic
- radon
- internal

Manufactured

- medical x-rays
- nuclear medicine
- consumer products
- occupational
- fallout
- nuclear fuel cycle
- miscellaneous

2. Create a chart of the following elements. Indicate the type of radioactivity emitted (alpha, beta, gamma) and the half life (in minutes, days, or years)

- Uranium-238
- Thorium-234
- Protactinium-234
- Uranium-234
- Thorium-230
- Radium-226
- Radon-222
- Polonium-218
- Lead-214
- Bismuth-214
- Polonium-214
- Lead-210
- Bismuth-210

- Polonium-210
- Lead-206

3. Create display materials that explain the difference between rads, rems, and millirems.

4. Have students describe different types of cell damage that may result from a radioactive exposure. What factors must be considered when describing the relationship between exposure and actual consequences? Hold a discussion on the hazards and benefits of exposure to radiation.



Task #3 – Issues and Concerns

"The nuclear industry denies our children a future, and instead condemns them to live on an irradiated planet among ever-growing piles of deadly radioactive waste. We are here to end nuclear colonization of our communities and commit ourselves and children to a nuclear free Northeast. "

- from the Citizens Awareness Network web site

Fear of the unknown drives people to extremes. In past times people have been sacrificed to the gods to stop volcanic eruptions, earthquakes, and disease. But as we learned more about these natural catastrophes, we learned that we could control some things and others we could not. Sacrifice within the "civilized" world no longer exists. Is this true within the nuclear world? Are issues and concerns based on lack of knowledge or do they have merit? Are people making decisions based on half-truths, selective fact dissemination, and fear? As Fox Mulder says, "The Truth is Out There."

Our third task focuses on the issues and concerns regarding the storage and disposition of radioactive waste. To understand these issues and concerns, we need to investigate them from the perspectives of pro- and anti- nuclear groups. Using this as reference point, focus your research on issues and concerns within the context of the four domains (scientific, economic, political, social/cultural).

Your task is to compare and contrast the different issues and concerns regarding radioactive wastes. You must examine differing perspectives regarding radioactive wastes, how they are stored and eventually disposed. Scrutinize the importance of disseminating factual data about radioactive wastes, storage and disposition, transportation, health hazards/benefits, the environment, etc. within the context of the four domains (science, economic, social/cultural, and political/geo-political). Research and gather data that help you build an understanding of the issues and concerns.

This task focuses on identifying issues and concerns regarding storage and disposition of radioactive wastes. Using this as your reference point, address the following:

1. Identify and describe three issues and concerns in the area of security of radioactive waste materials. Make a distinction between assumptions made by anti-nuclear activist groups and by pro-nuclear groups/agencies.
2. State a point-of-view from an anti-nuclear groups perspective regarding the legacy of the "Cold War" and nuclear state's weapons production. Which areas are justified

(supported by fact) within their conclusions and which areas are non-supported? Propose a rebuttal to their point-of-view that would be acceptable to them.

3. Develop a point-counterpoint script (60 Minutes style) on the transportation of radioactive waste materials from one state to a distant state. Include dialogue on

- security
- environment
- safety
- health

4. Design and develop a display regarding the safety issues for the shipment of low level radioactive waste materials. One part of the display should promote the Department of Energy's position and another part should promote the position of an anti-nuclear group. Compare the two positions and appraise the impact that each display would have on the general population.



Suggested Classroom Activities for Task #3

The following activities and questions are "hooks" for the work which is to come. While they are intended to generate discussion and promote understanding of and interest in the task, they are not directed specifically at any task question.

This task focuses on issues and concerns regarding radioactive waste. Using this as your reference point, address the following:

- 1.** Hold a class discussion on the use of low level radioactive waste material for a terrorist attack. Identify potential targets and impacts of such an event.
 - 2.** The legacy of the U.S. nuclear weapons program expands over the past 50+ years. Identify lessons learned from this legacy.
 - 3.** Since the end of the "Cold War", the U.S. and the former Soviet Union have been collaborating on issues dealing with radioactive materials (nuclear weapons, production facilities, and radioactive wastes). Discuss how this collaboration fits with the security issues of the United States.
 - 4.** Make a list of anti-nuclear groups. Identify their location, their philosophy, their agenda, and their most probable "targets".
 - 5.** Describe the effects of external exposure to alpha radiation from Plutonium.
 - 6.** Hold a class discussion on the hazards/benefits, strengths/weaknesses of energy production using:
 - coal
 - fuel oil
 - solar
 - wind
 - LEU
 - HEU
 - Pu
 - 7.** Role play a television interview on "Good Morning America with Charlie moderating" the dialogue between Dr. Helen Caldicott and Secretary Bill Richardson.
 - 8.** Develop and administer a questionnaire to determine issues and concerns of your local community toward shipment of radioactive wastes to the Waste Isolation Pilot Plant in Carlsbad, NM. Interpret the results of the questionnaire and hold a class discussion on how to address the identified issues and concerns.
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Task #4 – Laws and Regulations

Relations have been less than harmonious between the federal government and the states that either contain identified sites for radioactive waste management facilities or fear they may be next on the list. In fact, more than a dozen states, responding to pressure from their citizens, have enacted laws intended to prohibit flatly or to make it difficult to establish radioactive waste disposal facilities within their borders. However, such prohibitions on radioactive waste facilities may not pass constitutional review because of conflicts with the commerce clause of the U.S. Constitution.

Why do many states and local governments (and their general constituents) want to restrict or prohibit radioactive waste disposal and even temporary storage within their boundaries? Possible reasons include adverse experiences with other federal and private projects involving hazardous substances which have made states wary of possible future problems from radioactive waste facilities. Citizens and state and local officials want assurances that the facilities will be properly constructed and operated, and that they will pose no significant risks to people or to the environment now or in the future. Some want their states to play no part in disposal or storage under any conditions.

Western states feel they have long been targeted for hazardous facilities. These states have been sites for many federally sponsored hazardous activities in the past, including uranium mining, milling, and tailings disposal; nerve gas production, testing, and storage; and atomic bomb testing. Often, these remote locations were selected to minimize risk to the population at large. But as one Westerner put it, "The government has used the wide open spaces as a dumping ground for almost four decades and inflicted a lot of wounds on us. Well, we've just had enough." On the other hand, some people living near potential sites welcome radioactive waste repositories or storage facilities for the economic benefits they hope they will bring.

No legislation can guarantee agreement between states and the federal government. Problems are inevitable since state, local, and federal governments have different responsibilities and often different goals.

Our fourth task focuses on the laws and regulations regarding the storage and disposition of radioactive waste. To understand these laws and regulations and their impact, we need to investigate them from the perspectives of the various government entities and their represented constituencies. Using this as reference point, focus your research on laws and regulations within the context of the four domains (scientific, economic, political, social/cultural).

Your task is to compare and contrast the different laws and regulations (international, national, regional, and state) regarding the storage and disposition of radioactive wastes. You must examine differing perspectives that direct the creation of laws and regulations regarding radioactive wastes, how they are stored and eventually disposed. Scrutinize the importance of controlling, monitoring and inventorying radioactive wastes, storage and disposition, transportation, health hazards/benefits, the environment, etc. within the context of the four domains (science, economic, social/cultural, and political/geo-political). Research and gather data that help you build an understanding of the laws and regulations.

This task focuses on identifying issues and concerns regarding laws and regulations for the storage and disposition of radioactive wastes. Using this as your reference point, address the following:

- 1.** Governments play numerous roles in radioactive waste management. On one hand, they may be active promoters of nuclear research and development programs, but on the other hand, they are the regulators of things nuclear. This dual role often leads to complex relationships and overlaps between various governmental agencies. Identify and describe three areas where this complex relationship would seem to be in conflict with each other.
- 2.** State a point-of-view from an anti-nuclear groups perspective regarding the effectiveness of legislation governing the storage and disposition of radioactive wastes within your state boundaries. Which areas are justified (supported by fact) within their conclusions and which areas are non-supported? Propose a rebuttal (appropriate legislation) to their point-of-view that would be acceptable to them.
- 3.** As the governor of the Great State of "Not in my Back Yard", a state with a number of industries using/producing nuclear materials, propose legislation banning the storage and disposition of radioactive wastes within the state boundaries. What ideas would justify the ban and the eventual transportation of the "banned material" through the state and across other state lines.



Suggested Classroom Activities for Task #4

The following activities and questions are "hooks" for the work which is to come. While they are intended to generate discussion and promote understanding of and interest in the task, they are not directed specifically at any task question.

This task focuses on laws and regulations governing radioactive waste. Using this as your reference point, address the following:

- 1.** Role play a Senate debate on the need of creating a specialized agency with the Environmental Protection Agency (EPA) to regulate and monitor transportation and storage of radioactive wastes.
 - 2.** Design and develop a traveling display to inform the public of the governments point-of-view for the transportation of storage of radioactive wastes. One part of the display should promote the Department of Energy's position and another part should promote the position of an anti-nuclear group.
 - 3.** Develop an one-act play depicting lawful conflict between an anti-nuclear group and a government agency representative over the transportation of radioactive wastes through your community. Include major points of concern the activist group would likely have and the legislation that would support the government representative.
 - 4.** Identify laws regulating radioactive wastes in other countries.
 - 5.** Discuss the merits of producing legislation based on scientific knowledge today that is to govern disposition of the radioactive waste 10,000 years in the future.
 - 6.** Hold a class discussion on the hazards/benefits, strengths/weaknesses of storing radioactive wastes in your state.
 - 7.** Create a web page that informs your local community on current, past and future legislation dealing with radioactive waste. Include viewpoints of pro- and anti-nuclear groups, as well as the federal and state governments. Provide an area for general comments from community members on the issues. As the web site developers, you should moderate the dialogue generated by your site.
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Task #5 – Options

The United States and other nuclear countries have designed, built, maintained, and currently dismantled nuclear weapons within a large complex of facilities. Most of the nuclear facilities were constructed during the heydays of the "Manhattan Project and the Cold War.", the 1940's and 1950's. These facilities are aging, contaminated with radioactive wastes from decades of nuclear research and development projects, and existing in a period of time where the U.S. Department of Energy is closing and consolidating sites while at the same time modernizing others. The Department of Energy has, as a result of new laws passed during the last decade, begun a plan to alleviate the environmental, health, and safety (ESH) hazards resulting from these years of weapons development, production, and testing.

During the process of declassifying and cleaning up of former nuclear sites, the Department of Energy has realized the magnitude of the contamination. The severity and types of contamination vary greatly as does the types of waste. Contaminated soil, stored and buried transuranic, low level, and mixed wastes, and sometimes hazardous organic materials have moved beyond the boundaries of some facilities. The process of cleaning up the wastes has begun. New methods and technologies are being developed to attack the problem. But questions still arise. What do we do with the wastes? How do we mitigate the potential hazards for the general population as we begin to transport and store these wastes? These are perplexing problems faced by the Department of Energy. Past, current and future wastes must be contained, moved and stored, all within the limits of the law.

Federal laws require the Department of Energy to enter into several types of legal compliance agreements with the Environmental Protection Agency and state regulators. These agreements set procedures and schedules for meeting regulatory requirements. The laws and agreements have been established to ensure that the government acts to carry out existing and evolving policies set by Congress.

The Department of Energy has set a 30 year goal to clean up and restore the environment at its nuclear sites. Although considered unrealistically short, new technologies are being developed to help reach the mandate set by Congress.

Our fifth task focuses on the options regarding the storage and disposition of radioactive waste. To understand these options and their impact, we need to investigate them from the perspectives of science, the various government entities and their represented constituencies, the environmental, health and safety issues, and international acceptance.

Your task is to compare and contrast the different options for storage and disposition of radioactive wastes at the international, national, regional, and state levels. You must examine differing approaches regarding the transportation, storage, and disposition of radioactive wastes. Scrutinize the impact of each option within the context of the four domains (science, economic, social/cultural, and political/geo-political). Research and gather data that help you build an understanding of the laws and regulations.

This task focuses on identifying options for the storage and disposition of radioactive wastes. Using this as your reference point, address the following:

- 1.** Select one option for each of the following. Justify the use your selected option compared to other options.
 - treatment of radioactive wastes to reduce hazards
 - storage of radioactive wastes
 - disposing of radioactive wastes
- 2.** Develop a magazine article, replete with pictures, graphics, charts, and graphs, describing each of the options you selected above. Assume the article will be printed in a widely subscribed science magazine for the lay population. Criticize and defend each option.
- 3.** Propose an alternative for the disposition of excess plutonium from dismantled nuclear weapons that could be implemented by all of the nuclear states.



Suggested Classroom Activities for Task #5

The following activities and questions are "hooks" for the work which is to come. While they are intended to generate discussion and promote understanding of and interest in the task, they are not directed specifically at any task question.

This task focuses on options for storage and disposition of radioactive waste. Using this as your reference point, address the following:

- 1.** Identify and describe options for treating radioactive wastes. Create a chart giving the pros and cons for each option.
- 2.** Design and develop a traveling display to inform the public of the options for treating radioactive wastes. One part of the display should promote the Department of Energy's research and development, successes, and future methods while another part should promote the skepticism of an anti-nuclear group on these options.
- 3.** Hold a class discussion on the hazards/benefits, strengths/weaknesses of storing radioactive wastes in your state.
- 4.** Identify options for storing radioactive wastes. Describe possible reasons for each option.
- 5.** Identify options for disposing of radioactive wastes. Describe possible reasons for each option.
- 6.** Identify the methods currently being considered for the disposition of excess nuclear weapons grade material.
- 7.** Hold a class discussion on different options, and the impact of each within the four domains. Which option seems to be the best from your class discussion?

